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PREVENTIVE MAINTENANCE FOR EFFECTIVE OPERATION OF BOILERS IN KUWAIT INDUSTRY

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ABSTRACT

In this research study, preventive maintenance technique for improving the boiler efficiency is analysed with help of specific methodology. High efficiency can be achieved with the help of an optimal approach of the preventive method. In Kuwait. Among (80) participants, 62.5% of the participants were technical while 37.5% were engineers, the highest group 51.3% were 45 to 55 years old, 51% had master's degree, 42.5% had more than 10 years as experience and 28.8% working in steel industry. The participants' responses towards the preventive maintenance for efficient operation of boilers had high level with mean score > (3.57) out of (5) according to Likert scale; indicate a high level of agreements. The first rank was (It is required to clean the water side surfaces under preventive maintenance) with the highest mean score 3.9250, indicate that 78.5% of the total participants agreed about it. Last rank is observed (It is required to check the efficiency of boiler routinely by inspecting all major components) with the lowest mean score 3.2500, indicating that only 65% of the total participants agreed about it.

Result show that there is a significant difference in the degree of responds towards the preventive maintenance for efficient operation of boilers according to job in favor of engineers group.

There is a significant association between job and the following issues which concerned preventive maintenance for efficient operation of boilers, the higher the job as an engineer, the higher the approval score in the following issues:

- ***Preventive maintenance is more useful than other maintenance program.***
- ***It is required to purpose an efficient plan/ schedule for preventive maintenance of boiler.***

KEYWORDS: Boiler Efficiency & Engineers Group

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Original Article

1. INTRODUCTION

The heat recovery unit also significant unit of the boiler system as it flushes the solids from the working boiler. The maintenance and inspection should be done weekly and monthly to check up the lubrication, fuel and other components including the switches of the heat recovering unit. If any of the components needs the repair or replacement, then it should be replaced immediately under the preventive maintenance.

It is studied by Woon Bo beak et al. (2001) that the flame image is analyzed for fuel firing of the plant for low emission and safe operating system. The relationship between the flame observed, emission of gas and unburned fuel in furnace is studied. As, it all combined shows the condition of combustion of the burner, it is very important to put the condition monitoring and burner inspection and repair should be included in the preventive

maintenance with a pilot furnace.

In UK, the video camera are installed and mounted on the rear wall only to observe the oil gun flames at the time of start. When the boiler is fully loaded, the large flames showed to the rear wall leading the deposition of dust and ash because of these flames. A video display system is helped to monitor the combustion related activities. The condition of the combustion is determined by installing the Euclidean distance classifier (Jain, 2012). Principal value decomposition associates with the Euclidean classifier were used for the type of flame images (Jain, 2012). These images are formed on the basis of the combustion status of the boiler and used thereafter to know the status of the boiler for preventive maintenance.

2. SUBDIVISIONS OR TYPES OF THE PREVENTIVE MAINTENANCE

The preventive maintenance was divided into three subdivisions by oil and gas industry in Kuwait for the lengthy life of the equipment with keeping the safety of every employee in the mind. This subdivision covers the owner's manual and couples the annual preventive maintenance system.

These subdivisions of preventive maintenance are:

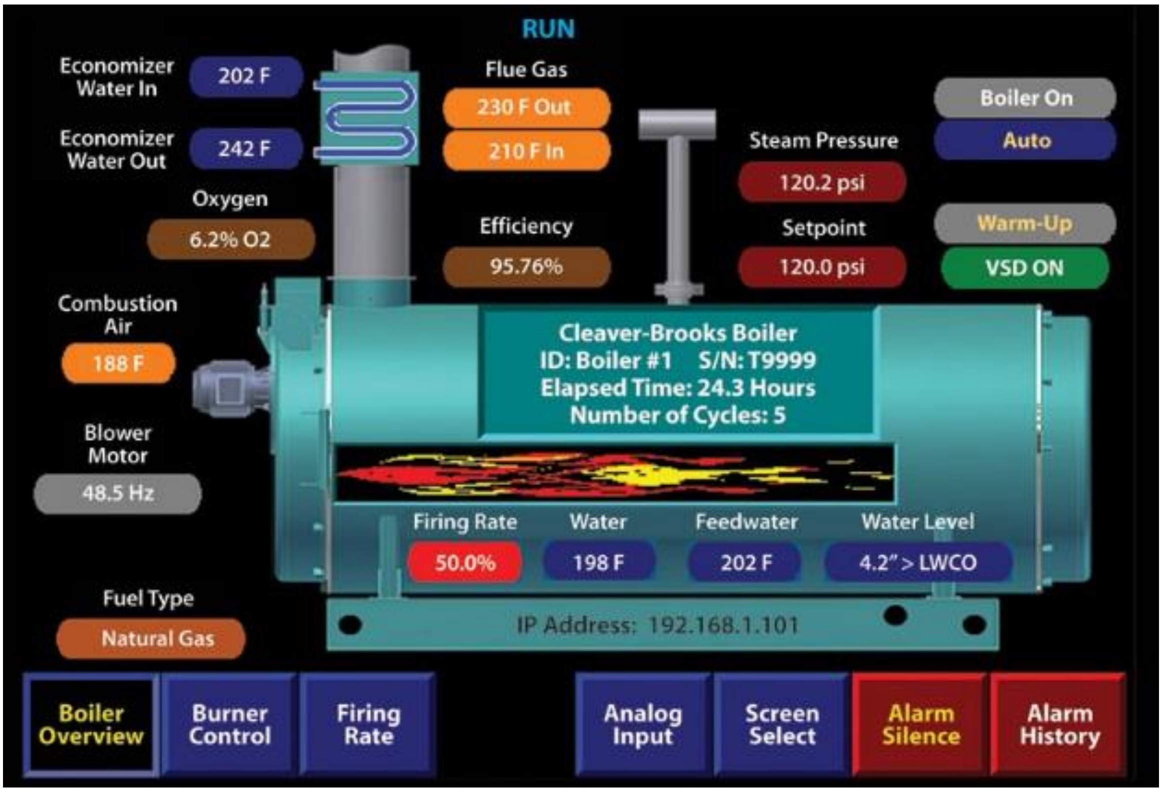


Figure 1: Advance Control System of the Boiler (Jain, 2012).

As the name suggest, an APH is an equipment used in a boiler to supply the heated air before the next operation. A series of these preheaters are used if a plant has a larger size. This not only supports the thermal efficiency of the boiler but also regulates the heat loss in the system. Hence, its maintenance, repair and replacement come at first place under the preventive maintenance. APH have many moving parts that associates its working mechanism and these moving parts mostly damage its own functioning. The damage can be controlled by the maintenance as the maintenance cost less than the replacement of the new part. In some cases, if this damage is higher than the expectations, then it is recommended to

change the moving parts under preventive maintenance period.

2.1 Research Objective

This research work aims to study the importance of a specific maintenance program known as preventive-maintenance.

2.1.1 Research Questions

- What are the parameters which are responsible for decreasing the boiler efficiency?
- Which factors should be included in the preventive maintenance program?
- Is there any significant association in the degree of responds towards the preventive maintenance for efficient operation of boilers according to job designation?

2.1.2 Research Hypothesis

- There is no significant difference in the degree of responds towards the preventive maintenance for efficient operation of boilers according to job.
- There is no significant association between job and responds towards the preventive maintenance for efficient operation of boilers.

2.2 Daily Maintenance

Clayton (2018) suggested that a quick daily check of a functioning and components of the boiler should be done to eliminate any major problems and malfunctioning of the boilers. If a potential issue is determined before causing loss and developing any serious case, then a quick healing check can work as a healing alternate or ointment that can knock out the issue from plant easily and can rectify the production of the plant.

The daily quick check of the boiler can include the checking of any leaking water, unwanted noises and hindrance. The technicians should make sure about the temperature and pressure readings of the boiler are under restraint level. Any error should be disclosed to the plant manager.

2.3 Periodic Maintenance

Periodic maintenance is the monthly or quarterly maintenances. The periodic maintenance can be called as the extensive or overall inspection of the boiler. There are many recommendations made under this kind of maintenance that is the combination of checking of air piping and gas ventilation piping. The leakage, blockage or wear of the pipes are checked including the discharge pipe connected to boiler and relief valve leaks. Any chokes and blockage checks of the drainage system also complete this maintenance.

The quarterly checking adds the extra checking that includes the inspection of the hydronic pipes, the burning flames and the water cut off of the boiler.

2.4 Annual Maintenance

The annual maintenance includes the testing of the boiler and its burner and components associates the boiler and there repairing and replacement, cleaning of the heat exchanger, proper wiring and connection lines and pH level of the water used in the boiler.

It is always recommended to choose the licensed professional once a year to perform the overall and comprehensive inspection and maintenance. The well trained and highly certified technician are hired to do the annually maintenance work. Figure 20 shows how the certified technicians are performing the annual preventive maintenance on the boiler and working in every detailed part of the boiler

3. RESEARCH METHODOLOGY

A total sample of (80) filled questionnaires were collected. All incomplete responses were deleted. The collected data were analyzed using (SPSS v.25) program: "Statistical Package for Social Sciences", as follow: Cronbach's alpha used to determine the reliability for the factors out from factor analysis. Descriptive statistics used to describe the basic features of the total in the study (80), such as frequencies, Percentages, Mean and Stander Deviation with rank. Independent sample T -test was performed to test the difference in the degree of responds towards the preventive maintenance for efficient operation of boilers according to job. Finally, Chi-square cross tabulation tests were used to test the association between job and responses toward the preventive maintenance for efficient operation of boilers.

3.1 DATA ANALYSIS

3.1.1 Reliability

In research involving multi-items scales, the Cronbach's alpha test is a widely applied method to determine the reliability of the scale as it helps to determine whether all items are measuring the same factor (De Vellis, 1991). In addition to the above, in order to measure the internal consistency of a survey instrument involving multi-item scales, it is essential to conduct a reliability test (Churchill, 1979). The term reliability refers to how well a test measures what it is supposed to measure (De Vellis, 1991). In this regard, the Cronbach's alpha test, also referred to as the coefficient alpha, is commonly used to measure the reliability or internal consistency of a dataset. Hence, in this study, this test was used to determine whether the scales used are reliable. Acceptable values of the Cronbach's alpha range between 0.70 and 0.95, although, as Tavakol and Dennick, (2011) note, low values could mean insufficient questions, poor levels of inter-relation between items or heterogeneous constructs. The basic rationale behind using this test is that the Cronbach's alpha ensures that the data being evaluated is reliable and effective for answering the research questions.

Cronbach's Alpha for the (20 items) was obtained.769, which suggests a good internal consistency (Pallant, 2007). Indeed, according to Nunnally (1978), a value of alpha (α) equivalent to 0.70 and above shows that the items of a scale can be deemed reliable. With respect to the in this research.

3.1.2 Demographic Characteristics

Demographics data for participants (N=80), shows that 62.5% of the participants were technical while 37.5% were engineers, the highest group 51.3% were 45 to 55 years old, 51% had master's degree, 42.5% had more than 10 years as experience and 28.8% working in steel industry. (Table 3.1)

Table 3.1: Demographic Characteristics (N=80)

Demographics Characteristics		N	%
Job	Engineer	30	37.5
	Technical	50	62.5
Age	24- 44 years	20	25.0
	45- 55 years	41	51.3
	Over 55 years	19	23.8

Education Level	Bachelor	24	30.0
	Master	41	51.3
	Ph.D.	15	18.8
How much professional experience do you have?	1 – 5 years	16	20.0
	6- 10 years	30	37.5
	> 10 years	34	42.5
In which type of industry, you are working?	Oil and gas industry	12	15.0
	Chemical industry	17	21.3
	Food industry	11	13.8
	Steel industry	23	28.8
	Cement industry	17	21.3

3.1.3. Descriptive Statistics

Descriptive Statistics of participants' responses were applied as Mean, Standard Deviation, all items had 5- point Likert scale, 1 for strongly disagree up to 5 for strongly agree; according to Pimentel, J. L. (2010), low level of agreements represented by mean score from 1 to 2.59, moderate level for 2.60 to 3.39 and high level of agreements for mean score 3.40 to 5 the highest degree.

Overall mean for participants' responses towards (Preventive maintenance for efficient operation of boilers) had mean (3.5700) out of (5) consider a (High) level of agreements with small value of St. D of (.55487); indicate that 671.4% of the total participants agree about the preventive maintenance for efficient operation of boilers. (Table 2)

Table 3.2: Descriptive Statistics for Preventive Maintenance for Efficient Operation of Boilers

	N	Minimum	Maximum	Mean	Std. Deviation	Rank
Preventive maintenance is more useful than other maintenance program	80	1.00	5.00	3.6625	1.28224	9
It is required to purpose an efficient plan/ schedule for preventive maintenance of boiler	80	1.00	5.00	3.7250	1.22190	7
Serious issues can be prevented with the help of routine inspections	80	1.00	5.00	3.4874	1.16916	12
Operating procedure of the boiler and its maintenance depend on each other	80	1.00	5.00	3.8125	1.31297	4
Pressure and temperature are two major parameters that should check at steady state in preventive maintenance	80	1.00	5.00	3.8500	1.24372	2
A good preventive maintenance program increases the life span of a boiler	80	1.00	5.00	3.4375	1.28125	13
A good preventive maintenance should include cleaning of combustion chamber for removing residue and debris	80	2.00	5.00	3.5125	1.13621	10
It is required to check the efficiency of boiler routinely by inspecting all the major component	80	1.00	5.00	3.2500	1.20652	20
Unstable water level can be an indication of water contamination what do you think it should be checked daily	80	1.00	5.00	3.3751	1.27662	16
What do you think preventative maintenance affect production time	80	1.00	5.00	3.4875	1.21169	11
It is required to check the steam pressure check daily under different loading condition	80	1.00	5.00	3.4250	1.38505	14
It is required to check the boiler blow down to improve the efficiency	80	1.00	5.00	3.3000	1.23657	19

It is required to make some type of adjustment to supply the specific flue gases compositions during the maintenance	80	1.00	5.00	3.3750	1.39052	17
Hydraulic and pneumatic valves must check in annual preventive maintenance schedule	80	1.00	5.00	3.3625	1.32401	18
System pumps and filters are required to inspect and reconditioned annually	80	1.00	5.00	3.8250	1.40321	3
It is required to clean the water side surfaces under preventive maintenance	80	1.00	5.00	3.9250	1.39416	1
For improving the boiler efficiency, boiler insulation should be checked monthly	80	1.00	5.00	3.7750	1.37772	5
Fuel flow, and flame conditions monitoring play important role for improving boiler efficiency	80	1.00	5.00	3.3875	1.40967	15
It is required to implement a new technology which is more expensive but efficient	80	1.00	5.00	3.6750	1.18829	8
The current procedure in the company is adequate for preventive maintenance	80	1.00	5.00	3.7500	1.26791	6
Overall	80	1.00	5.00	3.5700	.55487	

4. RESULTS AND DISCUSSIONS

4.1 Independent Sample T-Results

Independent sample T -test result show that here is a significant difference in the degree of responds towards the preventive maintenance for efficient operation of boilers according to job, in favour of engineer who had the highest mean (3.7917) out of (5), while technical group had the lowest mean (3.4370); since t=2.752 with p= 0.008< 0.05. (Figure 1)

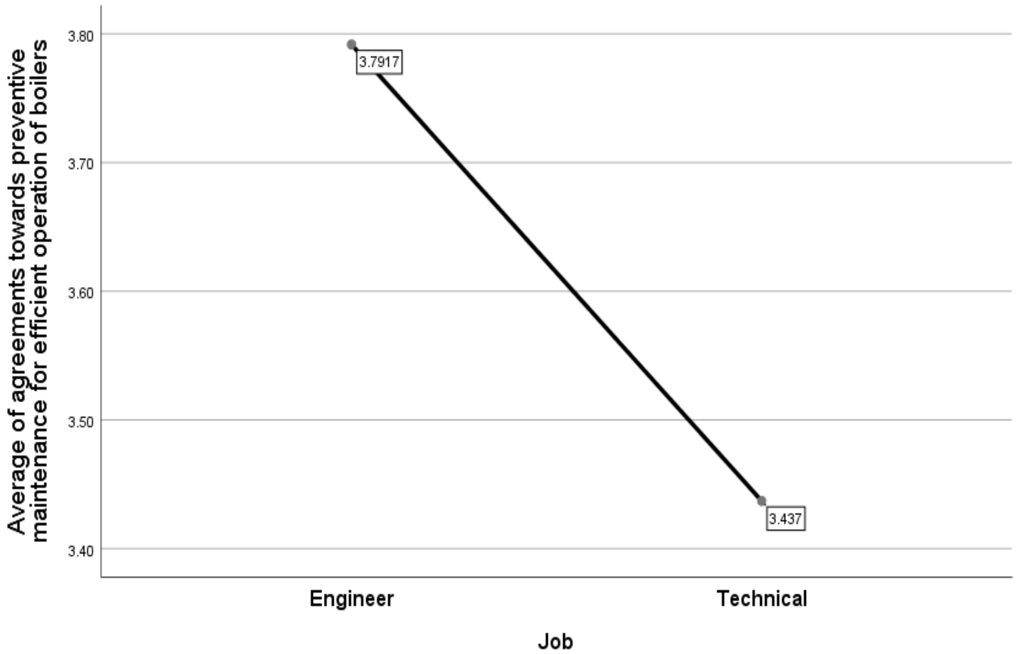


Figure 4.1: Independent T-Results.

4.2 Chi-Square Results

Table 4.1 show the cross tabulation between job and the item: (Preventive maintenance is more useful than other maintenance program), 20 engineers out of 30 with the highest percent 66.7% of engineers strongly agreed about this item

(preventive maintenance is more useful than other maintenance program), while 17 technical out of 50 with highest percent 34% of technical was neutral about it. (Table 3)

Table 4.1: Cross tabulation Table between Job and the Item: (Preventive Maintenance is more Useful than other Maintenance Program)

			Job		Total
			Engineer	Technical	
Preventive maintenance is more useful than other maintenance program	Strongly disagree	Count	3	1	4
		% within Job	10.0%	2.0%	5.0%
	Disagree	Count	4	10	14
		% within Job	13.3%	20.0%	17.5%
	Neutral	Count	0	17	17
		% within Job	0.0%	34.0%	21.3%
	Agree	Count	3	12	15
		% within Job	10.0%	24.0%	18.8%
	Strongly agree	Count	20	10	30
		% within Job	66.7%	20.0%	37.5%
Total		Count	30	50	80
		% within Job	100.0%	100.0%	100.0%
Pearson Chi-Square= 25.925, p-value = 0.000 < 0.05					

Pearson Chi-Square= 25.925, with p-value =.000 < 0.05, indicate that there is a significant association between job and responds towards the item (Preventive maintenance is more useful than other maintenance program); Engineers strongly agree with this item more than technicians. (Figure 4.2)

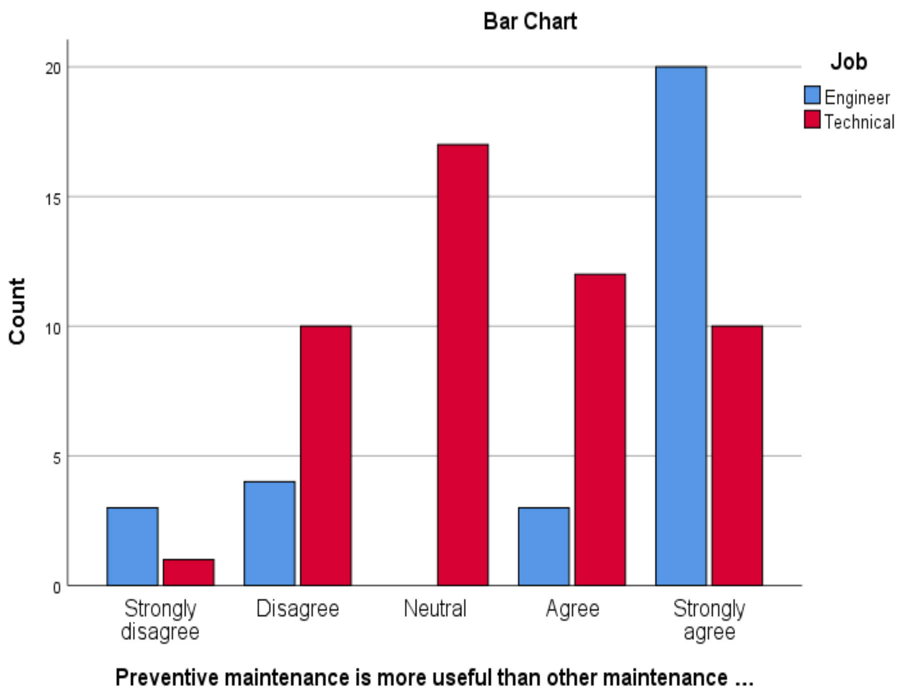


Figure 0.2: Chi Squares Results Plot.

The cross tabulation table between job and the item: (It is required to purpose an efficient plan/ schedule for preventive maintenance of boiler), 15 engineers out of 30 with the highest percent 50% of engineer strongly agreed about that it is required to purpose an efficient plan/ schedule for preventive maintenance of boiler, while 18 technical out of 50 with highest percent 36% of technical agreed about it. (Table 4.2)

Table 4.2: Cross Tabulation Table between Job and the Item: (It is Required to purpose an Efficient Plan/ Schedule for Preventive Maintenance of Boiler)

			Job		Total
			Engineer	Technical	
It is required to purpose an efficient plan/ schedule for preventive maintenance of boiler	Strongly disagree	Count	2	3	5
		% within Job	6.7%	6.0%	6.3%
	Disagree	Count	5	5	10
		% within Job	16.7%	10.0%	12.5%
	Neutral	Count	0	13	13
		% within Job	0.0%	26.0%	16.3%
	Agree	Count	8	18	26
		% within Job	26.7%	36.0%	32.5%
	Strongly agree	Count	15	11	26
		% within Job	50.0%	22.0%	32.5%
Total		Count	30	50	80
		% within Job	100.0%	100.0%	100.0%
Pearson Chi-Square= 13.506, p-value = 0.009 < 0.05					

Pearson Chi-Square= 13.506, with p-value = 0.009 < 0.05, indicate that there is a significant association between job and responds towards the item (t is required to purpose an efficient plan/ schedule for preventive maintenance of boiler); Engineers strongly agree with this item more than technicians. (Figure 4.3)

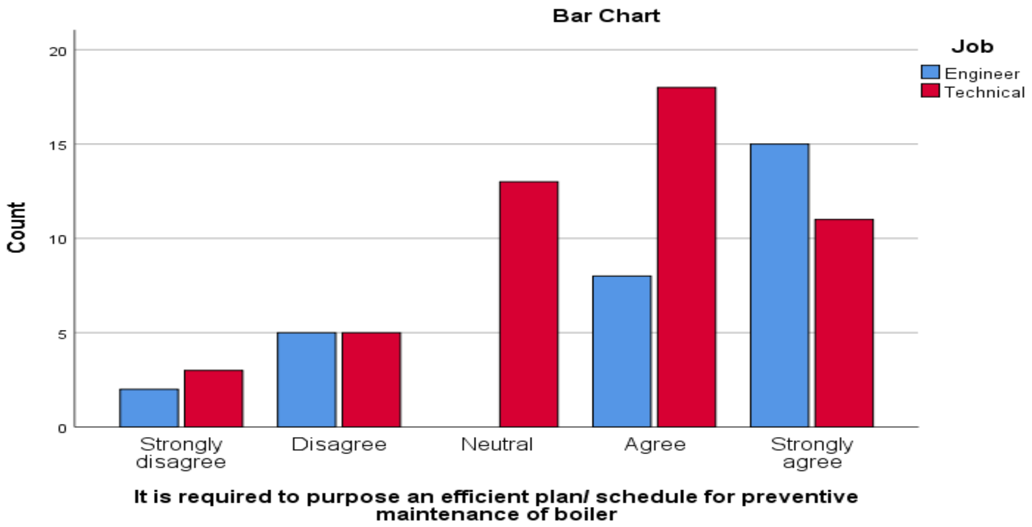


Figure 0.3: Chi Square Results for the Cross Tabulation between the Job and the Item.

The cross tabulation table between job and the item:(Serious issues can be prevented with the help of routine inspections), 10 engineer out of 30 with the highest percent 33.3% of engineers agreed that serious issues can be prevented with the help of routine inspections, also 16 technical out of 50 with highest percent 32% of technical agreed about it. (Table 4.4)

Table 4.3: Cross Tabulation Table between Job and the item: (Serious Issues can be Prevented with the help of Routine Inspections)

			Job		Total
			Engineer	Technical	
Serious issues can be prevented with the help of routine inspections	Strongly disagree	Count	2	4	6
		% within Job	6.7%	8.0%	7.5%
	Disagree	Count	4	5	9
		% within Job	13.3%	10.0%	11.3%
	Neutral	Count	7	15	22
		% within Job	23.3%	30.0%	27.5%
	Agree	Count	10	16	26
		% within Job	33.3%	32.0%	32.5%
	Strongly agree	Count	7	10	17
		% within Job	23.3%	20.0%	21.3%
Total		Count	30	50	80
		% within Job	100.0%	100.0%	100.0%
Pearson Chi-Square= 0.641, p-value = 0.958 > 0.05					

Pearson Chi-Square= 0.641, with p-value = 0.958 > 0.05, indicate that there is no significant association between job and responds towards the item (Serious issues can be prevented with the help of routine inspections)); Engineers and technicians agreed about it with approximately close percentages. (Figure 4.4)

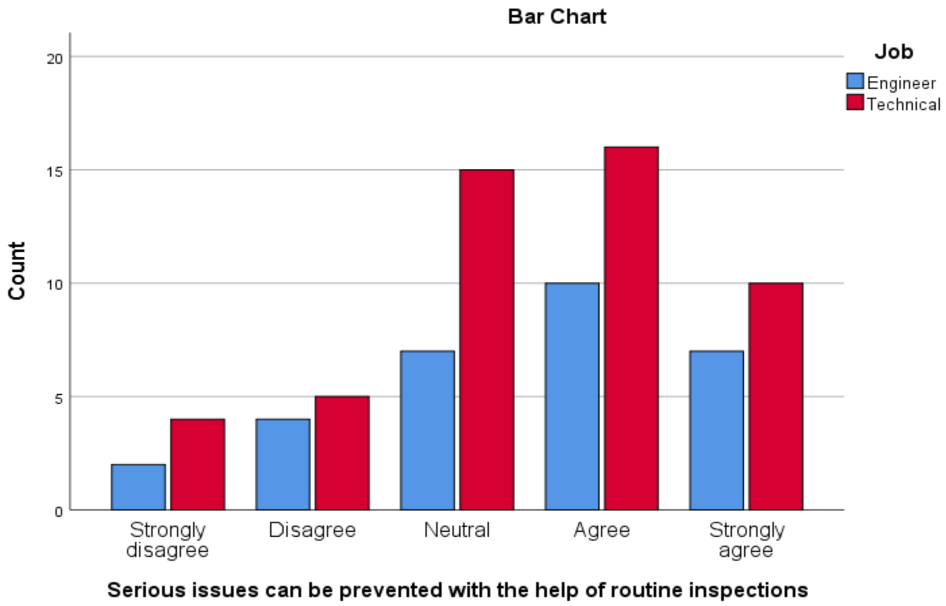


Figure 0.4: Results for Help Routine Inspection.

The cross tabulation table between job and the item:(Operating procedure of the boiler and its maintenance depend on each other), 15 engineers out of 30 with the highest percent 50% of engineers strongly agreed about that operating procedure of the boiler and its maintenance depend on each other, while 19 technical out of 50 with highest percent 38% of technical agreed about it. (Table 4.4)

Table 4.4: Cross Tabulation Table between Job and the Item: (Operating Procedure of the Boiler and its Maintenance Depend on Each other)

			Job		Total
			Engineer	Technical	
Operating procedure of the boiler and its maintenance depend on each other	Strongly disagree	Count	2	5	7
		% within Job	6.7%	10.0%	8.8%
	Disagree	Count	4	6	10
		% within Job	13.3%	12.0%	12.5%
	Neutral	Count	1	4	5
		% within Job	3.3%	8.0%	6.3%
	Agree	Count	8	19	27
		% within Job	26.7%	38.0%	33.8%
	Strongly agree	Count	15	16	31
		% within Job	50.0%	32.0%	38.8%
Total		Count	30	50	80
		% within Job	100.0%	100.0%	100.0%
Pearson Chi-Square= 3.199, p-value = 0.525 > 0.05					

Pearson Chi-Square= 3.199, with p-value = 0.525 > 0.05, indicate that there is no significant association between job and response towards the item (Operating procedure of the boiler and its maintenance depend on each other); Engineers and technicians agreed about it with approximately close percentages. (Figure 4.5)

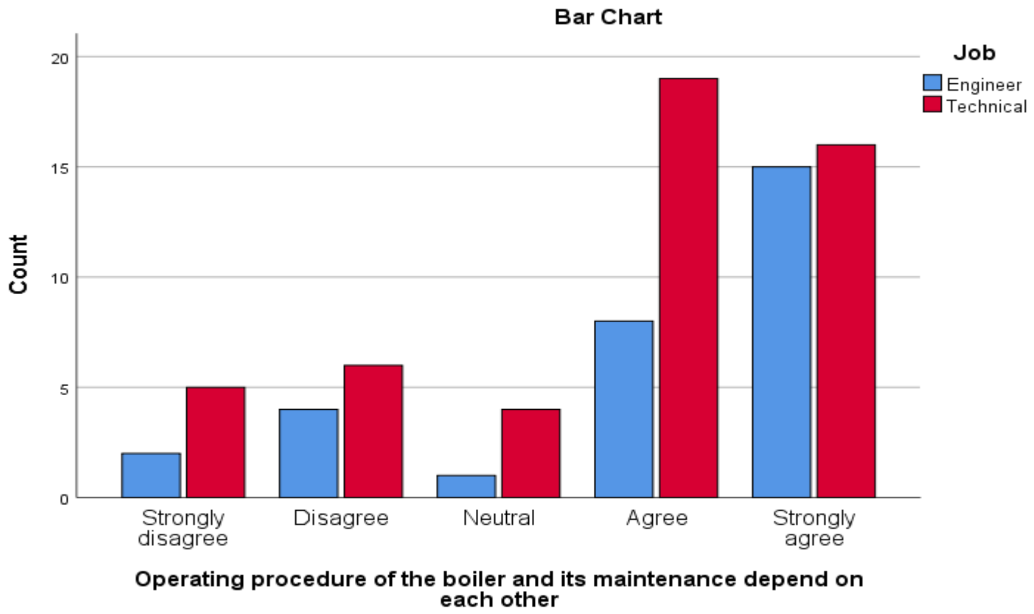


Figure 0.5: Results for Operating Procedure and its Maintenance.

The cross tabulation table between job and the item: (Pressure and temperature are two major parameters that should check at steady state in preventive maintenance), 12 engineers out of 30 with the highest percent 40% of engineers strongly agreed about that pressure and temperature are two major parameters that should check at steady state in preventive maintenance, also 23 technical out of 50 with highest percent 46% of technical strongly agreed about it. (Table 4.5)

Table 4.5: Cross Tabulation Table between Job and the Item: (Pressure and Temperature are Two Major Parameters that should Check at Steady State in Preventive Maintenance)

			Job		Total
			Engineer	Technical	
Pressure and temperature are two major parameters that should check at steady state in preventive maintenance	Strongly disagree	Count	0	2	2
		% within Job	0.0%	4.0%	2.5%
	Disagree	Count	6	9	15
		% within Job	20.0%	18.0%	18.8%
	Neutral	Count	3	8	11
		% within Job	10.0%	16.0%	13.8%
	Agree	Count	9	8	17
		% within Job	30.0%	16.0%	21.3%
	Strongly agree	Count	12	23	35
		% within Job	40.0%	46.0%	43.8%
Total		Count	30	50	80
		% within Job	100.0%	100.0%	100.0%
Pearson Chi-Square= 3.615, p-value = 0.461 > 0.05					

Pearson Chi-Square= 3.615, with p-value = 0.461 > 0.05, indicate that there is no significant association between job and responds towards the item (Pressure and temperature are two major parameters that should check at steady state in preventive maintenance); Engineers and technicians agreed about it with approximately close percentages. (Figure 4.6)

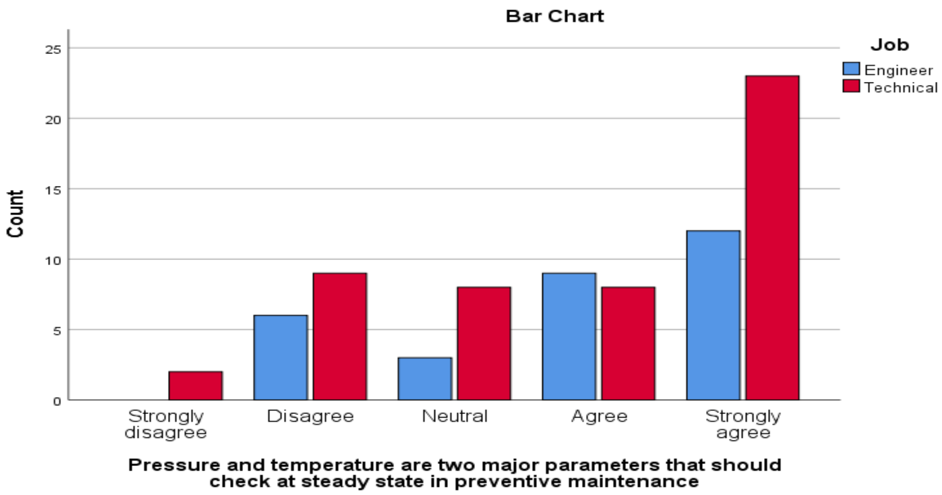


Figure 0.6: Pressure and Temperature Factor Results.

The cross tabulation table between job and the item: (A good preventive maintenance program increases the life span of a boiler), 10 engineers out of 30 with the highest percent 33.3% of engineers agreed that a good preventive maintenance program increases the life span of a boiler, also 15 technical out of 50 with highest percent 30% of technical agreed about it. (Table 4.6).

Table 4.6: Cross Tabulation Table between Job and the Item:
(A Good Preventive Maintenance Program Increases the Life Span of a Boiler)

			Job		Total
			Engineer	Technical	
A good preventive maintenance program increases the life span of a boiler	Strongly disagree	Count	1	4	5
		% within Job	3.3%	8.0%	6.3%
	Disagree	Count	9	11	20
		% within Job	30.0%	22.0%	25.0%
	Neutral	Count	3	7	10
		% within Job	10.0%	14.0%	12.5%
	Agree	Count	10	15	25
		% within Job	33.3%	30.0%	31.3%
	Strongly agree	Count	7	13	20
		% within Job	23.3%	26.0%	25.0%
Total		Count	30	50	80
		% within Job	100.0%	100.0%	100.0%
Pearson Chi-Square= 1.493, p-value = 0.828 > 0.05					

Pearson Chi-Square= 1.493, with p-value = 0.828 > 0.05, indicate that there is no significant association between job and response towards the item (A good preventive maintenance program increases the life span of a boiler); Engineers and technicians agreed about it with approximately close percentages. (Figure 4.7)

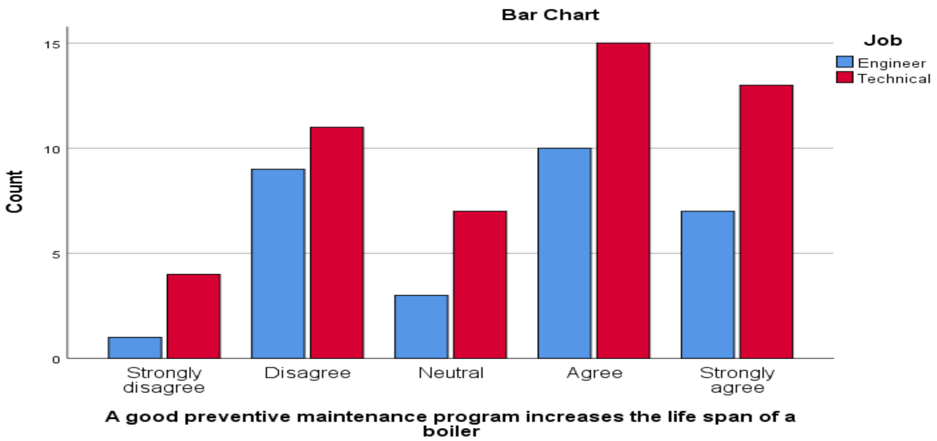


Figure 0.7: Preventive Maintenance Program Results.

The cross tabulation table between job and the item: (A good preventive maintenance should include cleaning of combustion chamber for removing residue and debris), 17 engineers out of 30 with the highest percent 56.7% of engineers

strongly agree/ agree that a good preventive maintenance should include cleaning of combustion chamber for removing residue and debris), while 21 technical out of 50 with highest percent 42% of technical (strongly agree/ agree) about it. (Table 4.7)

Table 4.7: Cross Tabulation Table between Job and the Item: (A Good Preventive Maintenance should Include Cleaning of Combustion Chamber for Removing Residue and Debris)

			Job		Total
			Engineer	Technical	
A good preventive maintenance should include cleaning of combustion chamber for removing residue and debris	Disagree	Count	6	13	19
		% within Job	20.0%	26.0%	23.8%
	Neutral	Count	7	16	23
		% within Job	23.3%	32.0%	28.8%
	Agree	Count	11	5	16
		% within Job	36.7%	10.0%	20.0%
	Strongly agree	Count	6	16	22
		% within Job	20.0%	32.0%	27.5%
Total		Count	30	50	80
		% within Job	100.0%	100.0%	100.0%
Pearson Chi-Square= 8.423, p-value = 0.038 < 0.05					

Pearson Chi-Square= 8.423, with p-value =.038 < 0.05, indicate that there is a significant association between job and responce towards the item (A good preventive maintenance should include cleaning of combustion chamber for removing residue and debris); Engineers strongly agree with this item more than technicians. (Figure 4.8)

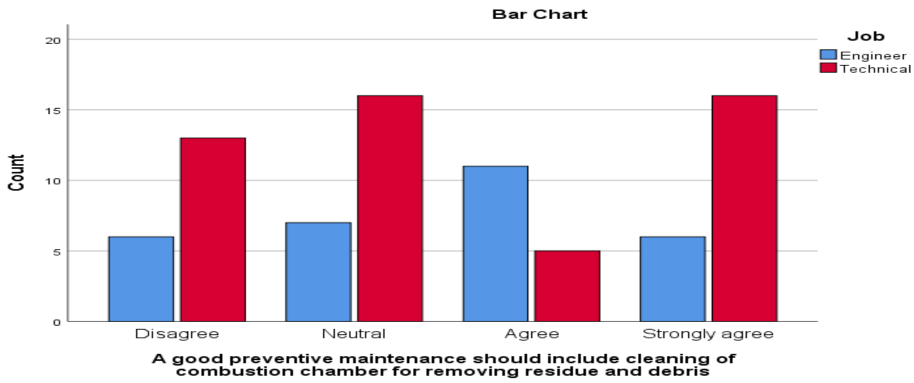


Figure 0.8: Results for the Preventive Maintenance Inclusion of Cleaning of Combustion Chamber for Residual Removal

The cross tabulation table between job and the item: (It is required to check the efficiency of boiler routinely by inspecting all the major component), 10 engineers out of 30 with the highest percent 33.3% of engineer were neutral about that it is required to check the efficiency of boiler routinely by inspecting all the major components, also 16 technical out of 50 with highest percent 32% of technical neutral about it. (Table 4.8)

Table 4.8: Cross Tabulation Table between Job and the item: (It is Required to check the Efficiency of Boiler Routinely by Inspecting all the Major Components)

			Job		Total
			Engineer	Technical	
It is required to check the efficiency of boiler routinely by inspecting all the major component	Strongly disagree	Count	1	8	9
		% within Job	3.3%	16.0%	11.3%
	Disagree	Count	5	5	10
		% within Job	16.7%	10.0%	12.5%
	Neutral	Count	10	16	26
		% within Job	33.3%	32.0%	32.5%
	Agree	Count	10	12	22
		% within Job	33.3%	24.0%	27.5%
	Strongly agree	Count	4	9	13
		% within Job	13.3%	18.0%	16.3%
Total		Count	30	50	80
		% within Job	100.0%	100.0%	100.0%
Pearson Chi-Square= 4.196, p-value = 0.380 > 0.05					

Pearson Chi-Square= 4.196, with p-value = 0.380 > 0.05, indicate that there is no significant association between job and responce towards the item (It is required to check the efficiency of boiler routinely by inspecting all the major components); Engineers and technicians were neutral about it with approximate close percentages. (Figure 4.9)

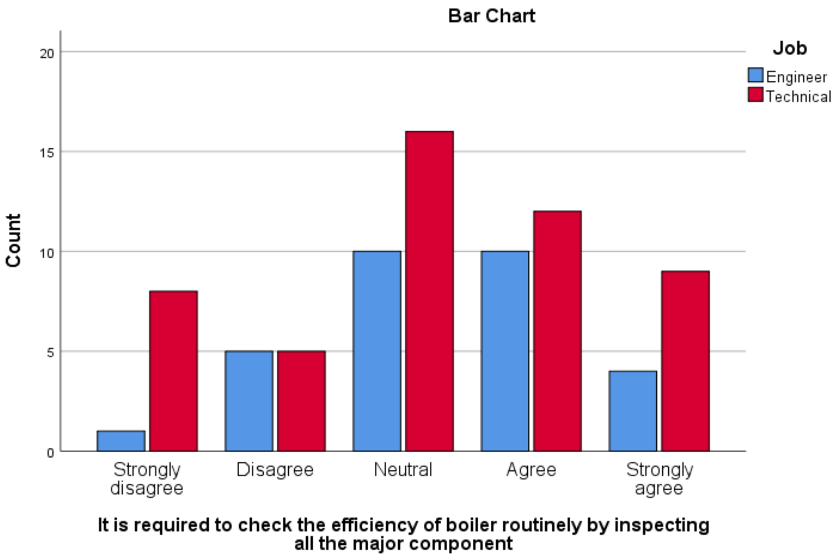


Figure 4.9: Results for Inspecting the Boiler Efficiency on Regular Interval

The cross tabulation table between job and the item: (Unstable water level can be an indication of water contamination and for the question, what do you think, it should be checked daily), 10 engineers out of 30 with the highest percent 33.3% of engineers neutral about that unstable water level can be an indication of water contamination what do you think it should be checked daily), also 17 technical out of 50 with highest percent 34% of technical neutral about it. (Table 4.9)

5. CONCLUSIONS

There is a significant association between job and the following issues which concerned preventive maintenance for

efficient operation of boilers, the higher the job as an engineer, the higher the approval score in the following issues:

- Preventive maintenance is more useful than other maintenance program.
- It is required to purpose an efficient plan/ schedule for preventive maintenance of boiler.
- A good preventive maintenance should include cleaning of combustion chamber for removing residue and debris.
- It is required to make some type of adjustment to supply the specific flue gases compositions during the maintenance.
- System pumps and filters are required to inspect and reconditioned annually.
- It is required to clean the water side surfaces under preventive maintenance.
- For improving the boiler efficiency, boiler insulation should be checked monthly.
- The current procedure in the company is adequate for preventive maintenance.

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